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(54) Inclined Plate Settling of Diluted Bitumen Froth

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"INCLINED PLATE SETTLING OF DILUTED BITUMEN FROTH"

ABSTRACT OF THE DISCLOSURE

'Diluted bituminous froth' is a product from the hot water extraction process for recovering bitumen from tar sand. This diluted froth is a mixture comprising bitumen, water, light hydrocarbon diluent, and particulate solids. In accordance with the invention, the diluted froth is treated in an inclined plate settler, before it enters the centrifuge circuit conventionally used to separate the components of the froth. The settler is controlled by varying its underflow withdrawal rate in response to the hydrocarbon content of the overflow from the settler, to maintain said overflow hydrocarbon content at a level which is sufficiently pure so as to be acceptable, after diluent removal, as feed to the downstream upgrading process. The underflow from the settler is passed to the centrifuge circuit to recover hydrocarbon therefrom. The composition of the underflow has been found to be less variable than the composition of the diluted froth feed, thereby making it easier to operate the centrifuge circuit.

FIELD OF THE INVENTION

The invention pertains to a process involving treating diluted bituminous froth, from the known hot water extraction process, by passing said diluted froth through an inclined plate settler to recover part of the contained bitumen in a form pure enough to be fed directly to the conventional downstream upgrading circuit.

BACKGROUND OF THE INVENTION

There are large surface deposits of tar sand in the Athabasca region of Alberta. These deposits are presently being produced by two large commercial plants, one of which is owned by the assignee of this application.

More particularly, these tar sand deposits are being mined and the valuable contained component, bitumen, is extracted and recovered by a process known as 'the hot water process'. The recovered bitumen is then upgraded in a refinery-type facility to produce hydrocarbon products having various commercial uses.

In this hot water process, the as-mined tar sand is introduced into a horizontal rotating drum, together with hot water and caustic. The mixture is retained in the drum for a short period while the ingredients mix, the tar sand is heated, and the components of the tar sand are dispersed in the water. The step is referred to as 'conditioning'. The slurry that emerges from the drum is diluted with additional hot water and screened to remove rocks and oversize lumps of tar sand. The screened slurry is passed into a thickener-like vessel (referred to as the 'PSV', for 'primary separation vessel'). Here the slurry is retained for a period of time under quiescent conditions. Bitumen globules, which have become aerated in the conditioning step, rise to the surface of the PSV contents and form a froth. This froth, called 'primary froth', is recovered. The primary froth has a bitumen content of about 65% by weight, the balance being

contaminants,in the form of water and solids. Most of the sand present in the slurry drops downwardly into the conical lower end of the PSV and is concentrated therein. The sand is removed through the bottom outlet. This stream, referred to as 'primary tailings', is discarded. Some bitumen, which has failed to ascend to the froth layer, and some solids remain in the watery layer between the froth and the concentrated sand. This mixture is referred to as 'middlings'. A stream of the middlings is continuously withdrawn from the PSV and advanced to sub-aerated flotation cells. Here the middlings are subjected to vigorous agitation and aeration. A froth layer is produced by the cells as a result of this treatment - the froth is referred to as 'secondary froth'. This secondary froth is 'dirtier' than the primary froth - it has a relatively high content of water and solids. The bitumen content is commonly only about 25%. The secondary froth is passed into a tank and retained for a period of time, to allow some of the solids and water to settle. The 'cleaned' secondary froth is decanted off and recombined with the primary froth to produce the 'combined froth product'.

This combined froth produce is not acceptable yet for processing in the upgrading circuit. The water and solids associated with the froth, partially in an emulsified form, must be removed to produce a hydrocarbon product which, after diluent removal, is suitable for upgrading. Such a product preferably is one containing at least 95% by weight hydrocarbon.

The cleaning of the combined froth product is conventionally accomplished by a process referred to as 'dilution centrifuging'.

Dilution centrifuging involves first adding naphtha to the combined froth product. This is done to give a less viscous hydrocarbon phase and to increase the density difference between the hydrocarbon phase and the water and solids phases. The resulting 'diluted froth' is now amenable to treatment in centrifuges to effect separation of the bitumen from the water and solids.

The commercially practised centrifuging process is carried out in a two step operation. More particularly, the diluted froth is first fed to a scroll-type centrifuge, which is adapted to remove the coarse solids from the feedstock. The hydrocarbon-rich product from the scroll centrifuge is then passed to a disc-type centrifuge, to separate the hydrocarbon from the remaining water and fine solids.

While the two stage centrifuging circuit has been used for years in the two plants in operation, there are a good many problems associated with it.

For example, one problem has to do with the fact that the composition of the diluted froth can vary quite widely, as a result of variations in the composition of the tar sand itself. The following compositions are typical of froth compositions for 'high' and 'low' quality froths that are produced in applicant's plant:

	High quality	Low quality
Hydrocarbon	80	55
Solids	5	8
Water	15	37

Taking the case of the disc centrifuge, it has internal components, (such as discs and nozzles) which have operating parameters (such as disc spacing and size of nozzles). Once these parameters are set, they cannot be changed while the machine is in operation. So once the parameter design is established for the machine, it has only a narrow range of froth compositions that it can handle, at normal operating speed.

To provide disc centrifuge capacity adequate to cope with the variable feed, it is therefore necessary to provide an excess of machines, some of which are therefore standing idle much of the time.

Another significant problem characterizing the centrifuge circuit is its very high maintenance cost. The wear on the machines, given the erosive nature of the mixture being processed, is almost prohibitive.

The reason that the centrifuge circuit is in fact used is that it leads to a final hydrocarbon product of the desired quality. Typically, the disc centrifuge product comprises:

Hydrocarbon	95% by wt.
Solids	4.5%
Water	0.5%

In summary then, there has long been a need for a separating means which could be inserted to supplement or partly substitute for the centrifuges. The added separating means should be characterized by:

- the capacity to produce a hydrocarbon product suitable after diluent removal for upgrading; and
- the capacity to improve the stream going on to the centrifuge circuit to reduce its variations in composition.

SUMMARY OF THE INVENTION

In accordance with the invention, diluted bituminous froth is passed through an inclined plate settler, before it is treated in the centrifuge circuit. The settler recovers a portion of the bitumen, contained in the froth, in the form of a hydrocarbon stream which is sufficiently pure to be acceptable, after diluent removal, as a product for feeding directly to the upgrading circuit.

The settler is controlled, to cope with variations in diluted bituminous froth composition and feed rate, by varying the withdrawal rate of underflow in response to the hydrocarbon content of the settler overflow. More particularly, the underflow withdrawal rate is varied to keep the overflow hydrocarbon content high enough that the overflow is accpetable for feeding directly to the upgrading circuit. Stated otherwise, the settler is operated at a cut intensity within the range of product withdrawal rates that give product of the desired quality.

The invention is characterized by a number of advantages:

(1) A machine free of moving parts and which works on the principle of gravity separation has surprisingly been discovered to yield a product comparable in quality to that produced by machines operating with the mechanism of powerful centrifugal separation;

(2) The settler yields a bitumen-containing underflow product which surprisingly has only limited variations in composition and which thus provides a much improved feed for the centrifuge circuit;

(3) And part of the cleaning/separating circuit for the diluted bituminous froth now takes the form of a settler which is substantially free of wear and maintenance problems.

Broadly stated, the invention is a process for treating diluted bituminous froth from the hot water process, which comprises passing the froth through an inclined plate settler to produce overflow and underflow streams and varying the underflow withdrawal rate from the settler in response to the hydrocarbon content of the overflow from the settler to maintain said overflow hydrocarbon content sufficiently high whereby it may be fed directly to an upgrading circuit.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic flowsheet showing in operating sequence a source of diluted bitumen froth, an inclined plate settler, and a centrifuge circuit;

Figure 2 is a triangular plot showing the variation in composition of diluted bitumen froth, as experienced in applicant's commercial plant; and

Figure 3 is a plot showing % oil recovery versus product quality for an inclined plate settler incorporated into a circuit in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A circuit in accordance with the invention is shown in Figure 1. This circuit was used in developing the present invention.

The circuit comprised a conventional source 1 of diluted bituminous froth. More particularly, the source 1 included a froth storage tank 2 which received bituminous froth from a hot water process plant (not shown). A source 3 of light hydrocarbon diluent, preferably naphtha, was also provided. The froth from the storage tank 2 was fed via line 4 and pump 5 to a diluent froth mixer 6. Naphtha was also fed, via line 7, into the mixer 6. A stream of diluted bituminous froth issued from mixer 6 and was fed via line 8 into an inclined plate settler 9. Overflow and underflow streams from the settler 9 issued through lines 10, 11 respectively. A pump 12 controlled the withdrawal rate through underflow line 11.

Typically, the diluted bituminous froth produced by the source 1 has a naphtha/bitumen ratio of about 0.6 to 0.8. The froth composition commonly falls within the enclosed area shown in Figure 2.

The inclined plate settler 9 used by applicant in the course of developing the present invention was a Model LGS 2500/45 unit available from Axel Johnson Inc. of Montreal. The settler parameters were as follows:

Dimensions:	height 4.6 m
	length 6.0 m
	width 3.7 m
Type of plates:	flat
Effective plate surface area:	350 m^2
Plate angle:	45°

The plates were adjustable to a limited extent - their spacing could be varied between 3.2 and 5.0 cms.

Applicant inserted the test settler 9 in its plant circuit immediately before its conventional centrifuge circuit (not shown), fed diluted froth to the settler, and passed the settler underflow on to the plant's centrifuge circuit.

In the course of testing the inclined plate settler 9 in this operation, applicants found that, if the settler was controlled by monitoring the settler overhead stream hydrocarbon content and varying the settler underflow withdrawal rate in response thereto, one could maintain the purity of the overflow stream at a value in the order of about 95%. More particularly, the underflow withdrawal rate was controlled by varying the speed of underflow pump 12, in response to periodic composition analyses of the overflow stream. Table I sets forth a comparison of the composition of a typical settler overflow product with a typical disc centrifuge product previously obtained with no settler in the line:

TABLE I

Component (wt%)	Disc Centrifuge	IPS
Hydrocarbon	94.7	95.3
Solids	0.8	0.8
Water	4.5	3.9

When the settler 9 was operated to produce an overhead product with a purity in accordance with Table I, it was found that about 75% to 85% of the hydrocarbon contained in the diluted froth could be recovered as overhead product.

In summary then, about 85% of the contained hydrocarbon in the diluted froth can be recovered as settler product having a purity in the order of about 95% hydrocarbon. This is supported by the data displayed in Figure 3.

It was also shown, when the settler 9 was tested, that the underflow product had a relatively constant composition. This provided a feed for the centrifuge circuit which was much easier to cope with than diluted froth. This is supported by the following typical data obtained during testing of the settler in the circuit:

Run A

feed	74% hydrocarbon
	20% water
	6% solids
hydrocarbon recovered from settler	85%
ratio of hydrocarbon/solids + water in the underflow	0.50

Run B

feed	66% hydrocarbon
	28% water
	6% solids
hydrocarbon recovered from settler	85%
ratio of hydrocarbon/solids + water in the underflow	0.50

SUPPLEMENTARY DISCLOSURE

It can be advantageous to operate the separation process with the feed froth at an elevated temperature. By operating at a higher temperature, the viscosity of the hydrocarbon is reduced. This allows the solid particles to settle more rapidly. In addition, at higher temperature, the water droplets coalesce more readily, which facilitates their separation from the hydrocarbon. A higher purity product can be produced with lower residence time.

At higher temperatures, fractions of the diluent can approach or exceed their atmospheric boiling point. To prevent flashing of the diluent and to contain the pressures generated, it is then necessary to operate the circuit at elevated pressure, using a controlled back pressure valve in the vent line from the settler.

In accordance with this aspect of the invention then, the circuit is made pressure-retaining using conventional means and the process is operated at elevated temperature and pressure.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A process for treating diluted bituminous froth from the hot water process, which comprises:

passing the froth through an inclined plate settler to produce overflow and underflow streams and varying the underflow withdrawal rate from the settler in response to the hydrocarbon content of the overflow from the settler to maintain said overflow hydrocarbon content sufficiently high whereby it may be fed directly to an upgrading circuit.

2. The process as set forth in claim 1 wherein:

the overflow hydrocarbon content is maintained at about 95% by weight.

CLAIMS SUPPORTED BY THE SUPPLEMENTARY DISCLOSURE

3. The process as set forth in claims 1 or 2 wherein:

the froth feed is at elevated temperature and the settler is maintained at elevated pressure.

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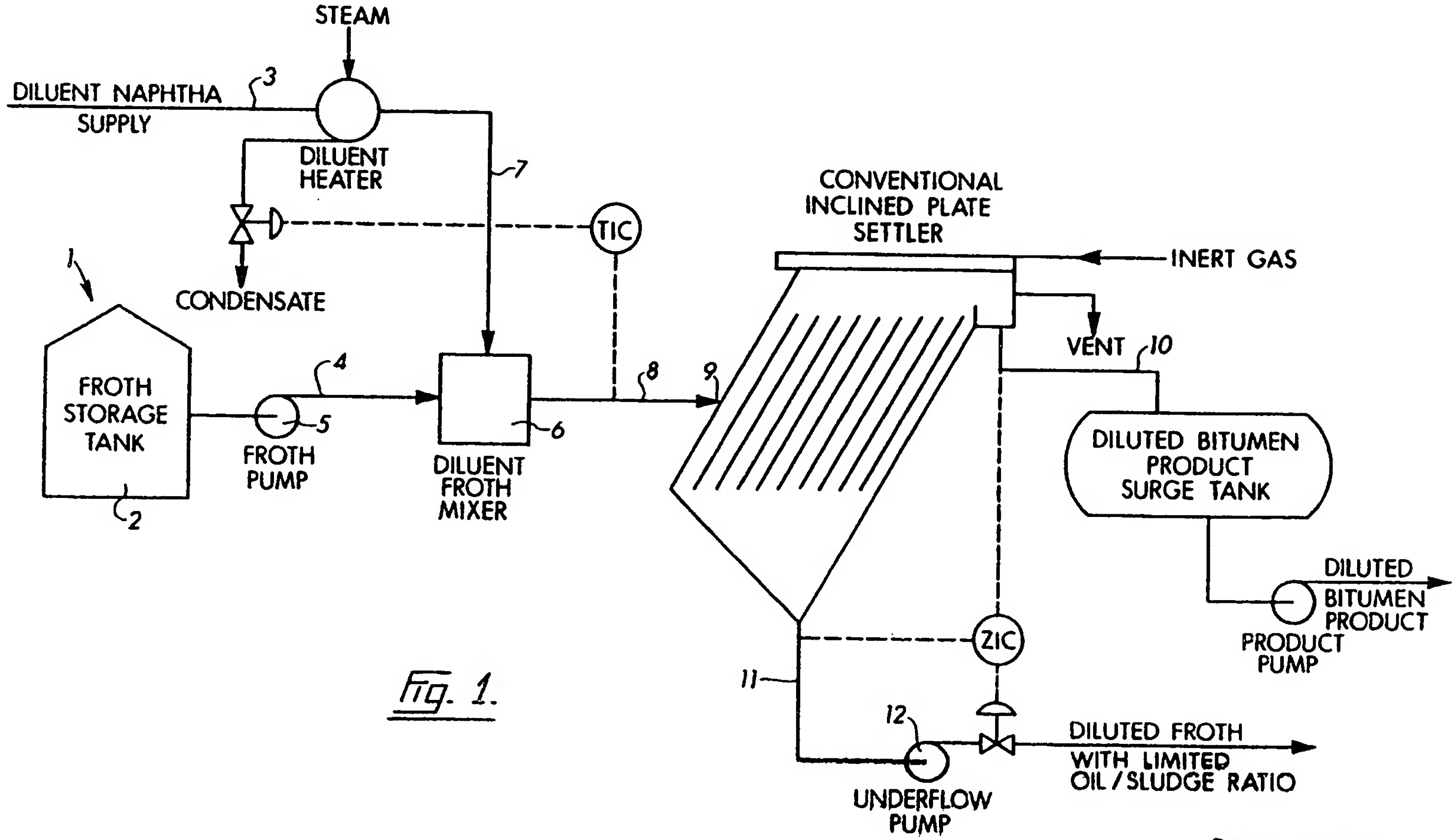

Fig. 1.

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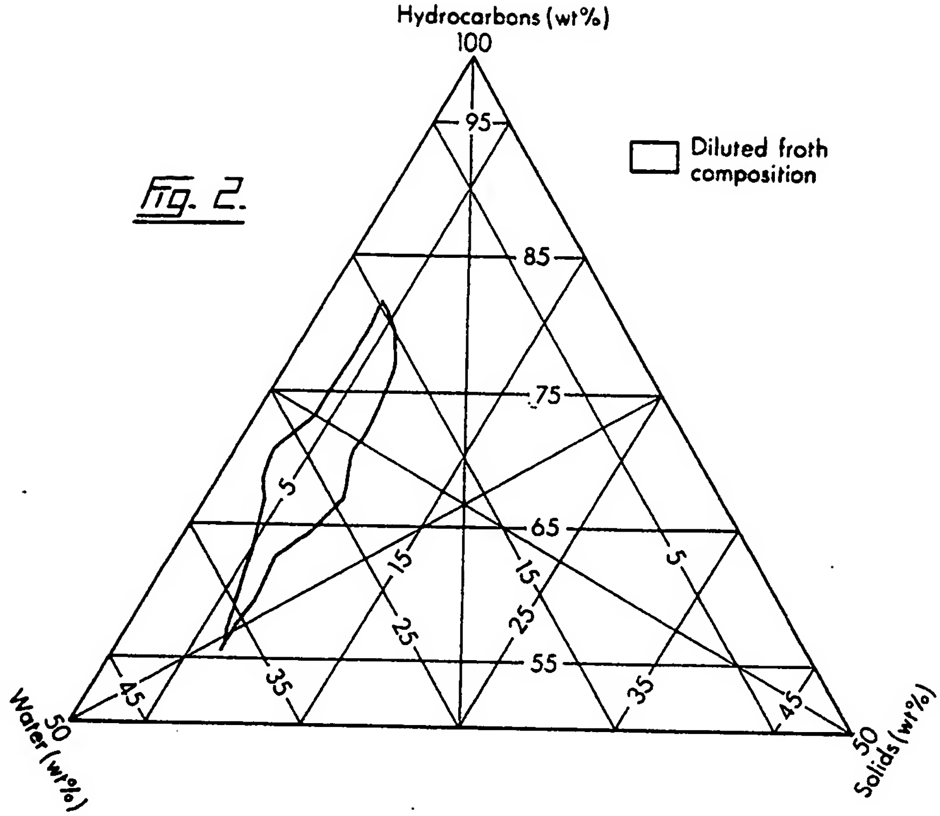
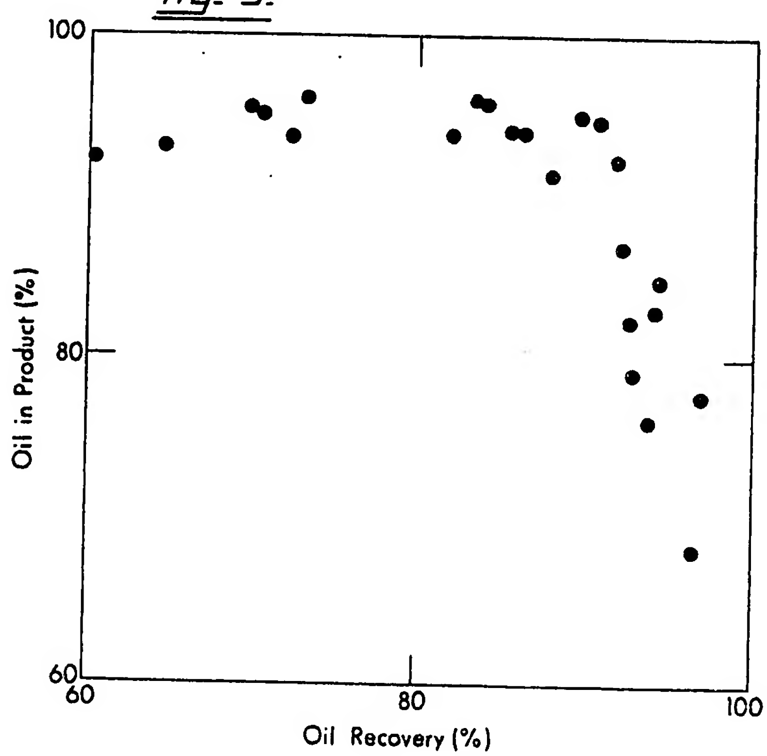


Fig. 2.

Fig. 3.



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